Disclosed herein are a washing machine and a control method thereof that is capable of supplying condensed water generated while laundry is dried to a steam generating unit (50) to generate steam, thereby minimizing formation of scale in the steam generating unit (50). The washing machine includes a drying unit (30) having a heat exchanger (35) to dehumidify air in a washing tub (11), a steam generating unit (50) to supply steam to the washing tub (11), a condensed water tank (60) to collect condensed water from the heat exchanger (35), and a steam-purpose water supplying unit (20) to supply the water from the condensed water tank (60) to the steam generating unit (50).

Fig. 1
Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a washing machine and a control method thereof, and, more particularly, to a washing machine with a laundry drying function and a steam supplying function and a control method thereof.

2. Description of the Related Art

[0002] Korean Unexamined Patent Publication No. 2005-43771 discloses a washing machine having a drying unit that dries laundry. The drying unit includes: a drying duct to circulate air in a water tub; a blowing fan to blow air in the drying duct; a heater to heat air supplied to the water tub through the drying duct; and a cooler to cool air passing through the drying duct such that moisture contained in the air is condensed to dehumidify air. Hot air is supplied into the water tub by the operation of the blowing fan and the heater, and high-humidity air is circulated in a closed circuit formed by the water tub and the drying duct. At this time, the cooler dehumidifies the air such that laundry is dried. The condensed water generated by the dehumidification of the cooler is usually drained out of the washing machine through a water draining pipe.

[0003] Korean Unexamined Patent Publication No. 2004-88884 discloses a washing machine having a steam generating unit to supply high-temperature steam into a drum such that laundry is more efficiently washed and sterilized. The steam generating unit includes: a pressure container to receive water; a heater to heat the water received in the pressure container such that steam is generated; and a steam channel to supply steam generated in the pressure container into the drum. The pressure container is connected to a water supply channel, through which water is supplied from an external water supply source to the pressure container.

[0004] In the steam generating unit of the washing machine, however, water is supplied from the external water supply source to the pressure container, and therefore, scale is formed on the inner surface of the pressure container or the outer surface of the heater due to calcium and magnesium that is contained in the water after the steam generating unit is used for a long period of time.

SUMMARY OF THE INVENTION

[0005] Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the invention.

[0006] Therefore, it is an aspect of the invention to provide a washing machine and a control method thereof that is capable of supplying condensed water generated while laundry is drying to a steam generating unit to generate steam, thereby minimizing the formation of scale in the steam generating unit.

[0007] In accordance with one aspect, the present invention provides a washing machine including: a drying unit having a heat exchanger to dehumidify air in a washing tub; and a steam generating unit to supply steam to the washing tub, wherein the washing machine further includes: a condensed water tank to collect condensed water from the heat exchanger; and a steam-purpose water supplying unit to supply the water from the condensed water tank to the steam generating unit.

[0008] Preferably, the steam-purpose water supplying unit includes: a steam-purpose water supplying pipe connected between the condensed water tank and the steam generating unit; a water supplying pump mounted on the water supplying pipe; and a water supplying valve to open and close the water supplying pipe.

[0009] Preferably, the washing machine further includes: a water level sensor to sense the water level of the condensed water tank; a water supplying unit to supply external water to the condensed water tank when the water level of the condensed water tank is below a predetermined water level; and a water draining unit to drain the water out of the condensed water tank when the water level of the condensed water tank is above the predetermined water level.

[0010] In accordance with another aspect, the present invention provides a control method of a washing machine including: a drying unit having a heat exchanger to dehumidify air in a washing tub; a steam generating unit to supply steam to the washing tub; and a condensed water tank to collect condensed water from the heat exchanger, wherein the control method includes: sensing the water level of the condensed water tank when a drying operation is performed; and opening a water draining pipe of the condensed water tank, when the water level of the condensed water tank is higher than a predetermined highest level, to drain water out of the condensed water tank.

[0011] Preferably, the control method further includes: closing the water draining pipe of the condensed water tank when the water level of the condensed water tank is lower than the predetermined highest level.

[0012] In accordance with yet another aspect, the present invention provides a control method of a washing machine including: a drying unit having a heat exchanger to dehumidify air in a washing tub; a steam generating unit to supply steam to the washing tub; and a condensed water tank to collect condensed water from the heat exchanger, wherein the control method includes: sensing the water level of the condensed water tank when steam is supplied to the washing tub; and operating the steam generating unit and supplying water from the condensed water tank to the steam generating unit through a steam-purpose water supplying unit when the water level of the condensed water tank is higher than a predetermined
lowest level.

[0013] Preferably, the control method further includes: supplying water to the condensed water tank from an external water supply source when the water level of the condensed water tank is lower than the predetermined lowest level.

[0014] Preferably, the control method further includes: stopping water supply to the condensed water tank from an external water supply source when the water level of the condensed water tank is higher than the predetermined lowest level.

[0015] Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] These and/or other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings, of which:

FIG. 1 is a view showing the structure of a washing machine according to the present invention;
FIG. 2 is a perspective view showing a heat exchanger of the washing machine according to the present invention;
FIG. 3 is a control block diagram to control the operation of the washing machine according to the present invention;
FIG. 4 is a flow chart illustrating a process of controlling a drying operation of the washing machine according to the present invention; and
FIG. 5 is a flow chart illustrating a process of controlling a steam supplying operation of the washing machine according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] Reference will now be made in detail to the embodiment of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. The embodiment is described below to explain the present invention by referring to the figures.

[0018] FIG. 1 is a view showing the structure of a drum type washing machine according to an embodiment of the present invention. As shown in FIG. 1, the drum type washing machine includes: a drum type washing tub 11 mounted in a machine body 10 to receive wash water; a rotary drum 12 rotatably mounted in the washing tub 11; the rotary drum 12 is attached to the rear center part of the washing tub 11 via a rotary shaft 13, which is attached to the rear center part of the rotary drum 12. At the outer rear part of the washing tub 11 is mounted a drive motor 14 to rotate the rotary drum 12. The rotary drum 12 has a plurality of through-holes 12a formed at the circumference thereof to allow wash water to be introduced into the rotary drum thereby, and a plurality of lifters 12b mounted at the inner surface thereof to lift laundry when the rotary drum 12 is rotated. At the front surface of the machine body 10 is formed an inlet/outlet hole 15, through which laundry is put into or removed from the rotary drum 12. The inlet/outlet hole 15 is opened or closed by a door 16 mounted to the front surface of the machine body 10.

[0020] The drum type washing machine further includes: a water supplying unit 20 to supply wash water into the washing tub 11; a detergent supplying unit 17 to supply detergent into the washing tub 11; a water draining unit 18 to drain water out of the washing tub 11; and a steam generating unit 50 to supply steam into the washing tub 11.

[0021] The water supplying unit 20 includes: a first water supplying valve 21 to control water supply from an external water supply source to the detergent supplying unit 17; a first water supplying pipe 22 connected between the first water supplying valve 21 and the detergent supplying unit 17; and a first water supply detergent into the washing tub 11; a water draining unit 18 to drain water out of the washing tub 11; a drying unit 30 to dry laundry in the rotary drum 12; and a steam generating unit 50 to supply steam into the washing tub 11.

[0023] The drying unit 30 blows heated air into the rotary drum 12 to dry laundry. The drying unit 30 includes: first and second ducts 31 and 32 disposed at the rear of the washing tub 11; third and fourth ducts 33 and 34 disposed above the washing tub 11; a condensation-purpose heat exchanger 35 mounted in the second duct 32; a blower 36 mounted in the connection part between the third duct 33 and the fourth duct 34; and a first heater 37 mounted in the fourth duct 34.

[0024] The inlet of the first duct 31 is connected to the lower part of the rear surface of the washing tub 11, the outlet of the fourth duct 34 is connected to the inlet side of the washing tub 11. The first to fourth ducts 31 to 34...
are connected to one another to from a continuous air circulating channel such that air is circulated in a closed circuit formed by the washing tub 11 and the first to fourth ducts 31 to 34.

[0025] The blower 36 includes: a blowing fan 36a to suction air guided through the third duct 33 and blow the suctioned air to the fourth duct 34; and a blowing motor 36b mounted at the outside of the fourth duct 34 to rotate the blowing fan 36a. The first heater 37 serves to heat air supplied into the washing tub 11 through the fourth duct 34 such that the heater air can dry the laundry in the washing tub 11.

[0026] As shown in FIGS. 1 and 2, the condensation-purpose heat exchanger 35 is a cylindrical sensible heat exchanger having first air channels 35a, through which air from the washing tub 11 passes, and second air channels 35b, through which outside air passes. The first air channels 35a intersect the second air channels 35b. The second duct 32, in which the heat exchanger 35 is mounted, includes: a first lower inlet 32a connected to the first duct 31; a first upper outlet 32b connected to the third duct 33; a second inlet 32c, through which outside air is introduced; and a second outlet 32d, through which the outside air is discharged. The direction in which the first inlet and outlet 32a and 32b are arranged intersects the direction in which the second inlet and outlet 32c and 32d are arranged. At the second inlet 32c is mounted an outside air blowing fan 38 (see FIG. 1) to blow the outside air. Although not shown in the drawings, the second inlet and outlet 32c and 32d of the second duct 32 communicate with the outside of the machine body 10 through additional ducts to accomplish circulation of outside air.

[0027] High-humidity air is introduced into the second duct 32 through the first inlet 32a from the washing tub 11, passes through the first air channels 35a of the heat exchanger 35, and flows to the third duct 33 through the first outlet 32b. Cold outside air is introduced into the second duct 32 through the second inlet 32c, passes through the second air channels 35b of the heat exchanger 35 such that heat exchange is performed, and is discharged out of the second duct 32 through the second outlet 32d. Moisture contained in the air passing through the first air channels 35a of the heat exchanger 35 is condensed to dehumidify the air. The above-described air circulation is repeated to dry the laundry.

[0028] According to an embodiment of the present invention, as shown in FIG. 1, condensed water generated while drying the laundry is collected and supplied to the steam generating unit 50 to generate steam. The condensed water has nearly the same purity as distilled water. Consequently, formation of scale in the steam generating unit 50 is minimized when steam is generated using the condensed water. The condensed water tank 60 to receive a predetermined amount of water is disposed below the second duct 32. The condensed water tank 60 is connected to the lower end of second duct 32 through a condensed water guide pipe 39. Consequently, water condensed in the heat exchanger 35 flows down the condensed water guide pipe 39, and is then collected in the condensed water tank 60.

[0029] The steam generating unit 50 includes: a metallic unit body 52 having a channel 51 defined therein; and a second heater 53 embedded in the unit body 52 to heat water passing through the channel 51 of the unit body 52 such that steam is generated. To the steam generating unit 50 are connected a steam-purpose water supplying unit 40 to supply water from the condensed water tank 60 to the steam generating unit 50 and a steam supplying pipe 44 to supply steam generated in the steam generating unit 50 to the washing tub 11. The steam-purpose water supplying unit 40 includes: a steam-purpose water supplying pipe 41 connected between the condensed water tank 60 and the steam generating unit 50; a water supplying pump 42 mounted on the water supplying pipe 41; and a third water supplying valve 43 to open and close the water supplying pipe 41. When the water supplying pump 42 is operated while the third water supplying valve 43 is opened, water is supplied from the condensed water tank 60 to the steam generating unit 50.

[0030] At the condensed water tank 60 is mounted a water level sensor 61 to sense predetermined highest level H and predetermined lowest level L in the condensed water tank 60. Also, a water draining pipe 62 is connected to the condensed water tank 60 to drain condensed water when the water level of the condensed water tank 60 is higher than the predetermined highest level H. On the water draining pipe 62 is mounted a second water draining valve 63 to open and close the water draining pipe 62. To the top part of the condensed water tank 60 is connected a third water supplying pipe 25, which is connected to the water supplying unit 20, such that water is supplied to the condensed water tank 60 when the water level of the condensed water tank 60 is below the predetermined lowest level L. The third water supplying pipe 25 is opened and closed by the second water supplying valve 24.

[0031] FIG. 3 is a control block diagram of the method to control the operation of the washing machine according to an embodiment of the present invention. As shown in FIG. 3, the washing machine further includes a signal input unit 71, a temperature sensor 73, a drying sensor 72, a water level sensor 71, and a control unit 70 to control the operation of the washing machine. The signal input unit 71 allows a user to input various operation information, such as washing course, water level, washing temperature, spin-drying time, drying, steam supply, etc., to the control unit 70. The temperature sensor 73 senses temperature in the washing tub 11 and transmits the sensed temperature to the control unit 70. The drying sensor 72 senses the drying degree of laundry. The water level sensor 71 senses water level of the condensed water tank 60 and transmits the sensed water level to the control unit 70.

[0032] The control unit 70 controls the operations of the motor 14, the first and second water supplying valves 21 and 24, the first water draining valve 18b, the blower
controlling a steam supplying operation of the washing machine according to an embodiment of the present invention. As illustrated in FIG. 5, the control unit 70 controls the water level sensor 61 of the condensed water tank 60 to sense the level of the condensed water collected while the laundry is being dried based on a steam supplying signal inputted through the signal input unit 71 (91), and determines whether the water level of the condensed water tank 60 is higher than the predetermined minimum level L (92). It should be noted that the predetermined minimum level L is not a level that indicates that there is no water in the condensed water tank 60. The predetermined minimum level L is a level indicating that there is a minimum amount of water sufficient to generate steam in the condensed water tank 60.

When the control unit 70 determines that the water level of the condensed water tank 60 is higher than the predetermined minimum level L, that indicates that there is a minimum amount of water sufficient to generate steam in the condensed water tank 60, the second water supplying valve 24 is opened such that water is supplied into the condensed water tank 60 (93). On the other hand, when the control unit 70 determines that the water level of the condensed water tank 60 is lower than the predetermined minimum level L, the second water supplying valve 24 is opened such that water is supplied from the external water supply source to the condensed water tank 60 (94).

When the control unit 70 determines that the water level of the condensed water tank 60 exceeds the predetermined minimum level L, the second heater 53 of the steam generating unit 50 operates (95). Also, the water supplying pump 42 of the steam purpose water supplying unit 40 operates and the third water supplying valve 43 is opened such that the condensed water, which has nearly the same purity as distilled water, is supplied to the steam generating unit 50 to generate steam (96). As described above, only the condensed water, which has nearly the same purity as distilled water, is supplied to the steam generating unit 50 when the water in the condensed water tank 60 exceeds the predetermined minimum level L. Consequently, the formation of scale in the steam generating unit 50 is minimized. When the water level of the condensed water tank 60 is lower than the predetermined minimum level L, on the other hand, the second water supplying valve 24 is opened such that external water is supplied into the condensed water tank 60, and thus, the condensed water tank 60 supplies the water to the steam generating unit 50.

The steam generating unit 50 supplies steam into the washing tub 11 through the steam supplying pipe 44. While the steam is supplied, the control unit 70 controls the temperature sensor 73 of the washing tub 11 to sense the temperature of the washing tub 11 (97), and determines whether the interior of the washing tub 11 is sufficiently heated to a temperature predetermined by a user or when steam supplying time predetermined by the user elapses (98). This determination depends on the steam supplying condition selectively inputted by the us-
er (for example, the temperature of the washing tub or steam supplying time).

When the temperature of the washing tub 11 exceeds the predetermined level, or the predetermined steam supplying time elapses, the steam supply is stopped. In the event that the temperature of the washing tub 11 does not exceed the predetermined level, or the predetermined steam supplying time does not elapse, the above steam supplying operation controlling process is repeated.

As apparent from the above description, the condensed water generated while drying laundry is supplied to the steam generating unit to generate steam, whereby the formation of scale in the steam generating unit is minimized.

Furthermore, the external water supply source supplies water into the condensed water tank when the condensed water is not sufficient in the condensed water tank, whereby water is easily supplemented in the condensed water tank.

In the above-described embodiments, the condensed water is reused in a steam supplying operation that can heat the water, steam the wet laundry and steam dry wrinkled laundry. It is also possible to use and reuse the condensed water, with almost the purity of distilled water, as a supply of water, heated or unheated, to the washing operation, such as during washing or rinsing, using the steam supply system and controlling heat supplied to the water by the steam unit.

Although a few embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in this embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

Claims

1. A washing machine, comprising:
   - a drying unit having a heat exchanger to dehumidify air in a washing tub;
   - a steam generating unit to supply steam to the washing tub;
   - a condensed water tank to collect condensed water from the heat exchanger; and
   - a steam-purpose water supplying unit to supply water from the condensed water tank to the steam generating unit.

2. The washing machine according to claim 1, wherein the steam-purpose water supplying unit comprises:
   - a steam-purpose water supplying pipe connected between the condensed water tank and the steam generating unit;
   - a water supplying valve to open and close the steam-purpose water supplying pipe.

3. The washing machine according to claim 1, further comprising:
   - a water level sensor to sense the water level of the condensed water tank;
   - a water supplying unit to supply external water to the condensed water tank when the water level of the condensed water tank is below a first predetermined water level; and
   - a water draining unit to drain the water out of the condensed water tank when the water level of the condensed water tank is above a second predetermined water level.

4. A control method of a washing machine comprising:
   - a drying unit having a heat exchanger to dehumidify air in a washing tub; a steam generating unit to supply steam to the washing tub; and a condensed water tank to collect condensed water from the heat exchanger, wherein the control method comprises:
     - sensing the water level of the condensed water tank when a drying operation is performed; and
     - opening a water draining pipe of the condensed water tank, when the water level of the condensed water tank is higher than a predetermined highest level, to drain water out of the condensed water tank.

5. The control method according to claim 4, further comprises:
   - closing the water draining pipe of the condensed water tank when the water level of the condensed water tank is lower than the predetermined highest level.

6. A control method of a washing machine comprising:
   - a drying unit having a heat exchanger to dehumidify air in a washing tub; a steam generating unit to supply steam to the washing tub; and a condensed water tank to collect condensed water from the heat exchanger, wherein the control method comprises:
     - sensing the water level of the condensed water tank when steam is supplied to the washing tub; and
     - operating the steam generating unit and supplying water from the condensed water tank to the steam generating unit through a steam-purpose water supplying unit when the water level of the condensed water tank is higher than a predetermined lowest level.
7. The control method according to claim 6, further comprising:

supplying water to the condensed water tank from an external water supply source when the water level of the condensed water tank is lower than the predetermined lowest level.

8. The control method according to claim 7, further comprising:

stopping water supply to the condensed water tank from an external water supply source when the water level of the condensed water tank is higher than the predetermined lowest level.

9. A subassembly of a washing machine, comprising:

a condensed water tank to collect condensed water for the operation of the washing machine;
a water level sensor to sense a water level of the tank;
a water supplying unit to supply external water to the tank when the water level sensor detects that the water level of the tank is below a first predetermined level; and
a water draining unit to drain excess water out of the tank when the water level sensor detects when the water level of the tank is above a second predetermined water level.

10. A washing machine, comprising:

a drying system condensing water during drying of laundry in a washing tub; and
a washing system for using the condensed water during a washing related operation for laundry in the tub.

11. A washing machine as recited in claim 10, wherein the washing related operation is supplying steam to the laundry.

12. A washing machine process, comprising:

controlling a washing machine to condense water during drying of laundry; and
controlling the washing machine to use the condensed water during washing related operations for the laundry.
Fig. 3

- Signal input unit
- Drying sensor
- Temperature sensor
- Water level sensor
- Drive motor
- First water supplying valve
- Second water supplying valve
- First water draining valve
- Blower
- Outside air blowing fan
- First heater
- Second heater
- Water supplying pump
- Third water supplying valve
- Second water draining valve

Control unit
Fig. 4

1. Start drying operation

2. Operate drive motor
   Operate first heater
   Operate blower
   Operate outside air blowing fan

3. Sense water level of condensed water tank

4. Higher than predetermined highest level?
   - Yes: Open second water draining valve
   - No: Close second water draining valve

5. Sense drying degree

6. Sufficient dryness?
   - No: Continue
   - Yes: End drying operation
Fig. 5

start steam supplying operation

91 sense water level of condensed water tank

92 higher than predetermined lowest level?

no

94 open second water supplying valve

yes

93 close second water supplying valve

95 operate second heater

96 operate water supplying pump & open third water supplying valve

97 sense temperature of washing tub

no

98 above predetermined temperature or time?

yes

end steam supplying operation
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